

Ranking Scales for Design-FMEA: Comparison of SAE J1739 / AIAG / VDA / yellow volume / proposal i-Q



SEVERITY – Design-FMEA

S	SAE J1739 (status: 01/2009)	AIAG, FMEA 4 th edition (status: 06/2008)	VDA volume 4-II (status: 06/2012)	VDA/AIAG yellow volume (status: 11/2017)	Proposal i-Q Schacht & Kollegen GmbH (status: 03/2018)
10	Safety and / or Regulatory Compliance Potential failure mode affects safe vehicle operation and / or involves noncompliance with government regulation without warning.	Failure to Meet Safety and / or Regulatory Requirements Potential failure mode affects safe vehicle operation and / or involves noncompliance with government regulation without warning.	Very high Extremely severe failure that affects the safety and / or violates the compliance to legal regulations. Existence-endangering risk to the company.	Affects safe operation of the vehicle and / or other vehicles, the health of operator or passenger(s) or road users or pedestrians.	Very high severity: Potential failure mode affects safe vehicle operation. Health and life of humans are endangered. It could lead to an existence threatening company risk.
9	Safety and / or Regulatory Compliance Potential failure mode affects safe vehicle operation and / or involves noncompliance with government regulation with warning.	Failure to Meet Safety and / or Regulatory Requirements Potential failure mode affects safe vehicle operation and / or involves noncompliance with government regulation with warning.	Very high Extremely severe failure that affects the safety and / or violates the compliance to legal regulations. Existence-endangering risk to the company.	Noncompliance with regulations	Very high severity: Potential failure mode involves noncompliance with government regulation. Humans are not endangered.
8	Primary Function – Essential Loss of primary function (vehicle inoperable, does not affect safe vehicle operation)	Loss or Degradation of Primary Function Loss of primary function (vehicle inoperable, does not affect safe vehicle operation).	High Operability of the vehicle heavily limited and / or loss of functions that are necessary for normal driving. Immediate stay in the garage is imperatively necessary.	Loss of essential vehicle function necessary for normal driving during expected service life.	The vehicle is inoperable. Driving is not possible. The customer is extraordinary dissatisfied. (<i>Loss of primary function – walk home – vehicle stands still => driver has to walk. Vehicle slows down, no hazard of an accident.</i>) System cannot be assembled / flashed at the final assembly at the OEM (line stopper).
7	Primary Function – Essential Degradation of primary function (vehicle operable, but at reduced level of performance)	Loss or Degradation of Primary Function Degradation of primary function (vehicle operable, but at reduced level of performance).	High Operability of the vehicle heavily limited and / or loss of functions that are necessary for normal driving. Immediate stay in the garage is imperatively necessary.	Degradation of essential vehicle function necessary for normal driving during expected service life.	The vehicle is operable, but at a reduced level. The customer is very dissatisfied. Immediate stay in the garage is imperatively necessary. (<i>Limp home – vehicle can be driven in reduced mode only, e.g. limitation of maximum revolution.</i>) System cannot be assembled / flashed at the final assembly at the tier 1 (line stopper).
6	Secondary Function – Convenient Loss of secondary function (vehicle operable, but comfort / convenience functions inoperable)	Loss or Degradation of Secondary Function Loss of secondary function (vehicle operable, but comfort / convenience functions inoperable).	Moderate Operability of the vehicle limited, immediate stay in the garage is not necessary. Loss of important service and comfort systems.	Loss of convenience function.	The vehicle is operable, but comfort functions are not available. The customer is dissatisfied. (<i>Air condition is not working, window cannot be opened, Hybrid has no function.</i>) System cannot be assembled at the pilot belt or fails at the end of line test at the Tier 1.
5	Secondary Function – Convenient Degradation of secondary function (vehicle operable, but comfort / convenience functions at reduced level of performance)	Loss or Degradation of Secondary Function Degradation of secondary function (vehicle operable, but comfort / convenience functions at reduced level of performance).	Moderate Operability of the vehicle limited, immediate stay in the garage is not necessary. Loss of important service and comfort systems.	Degradation of convenience function.	The vehicle is operable, but comfort functions are working at a reduced level. The customer is somewhat dissatisfied. (<i>Air condition is not working properly, window opens slowly, Hybrid has no full function.</i>) System cannot be assembled at the prototype building / set into function or fails at the function test.
4	Annoyance Appearance or Audible Noise, vehicle operable, item does not conform. Defect noticed by most customers (>75%)	Annoyance Appearance or Audible Noise, vehicle operable, item does not conform and noticed by most customers (>75%).	Moderate Operability of the vehicle limited, immediate stay in the garage is not necessary. Loss of important service and comfort systems.	Perceived quality of appearance, sound or haptics unacceptable to most customers.	Fit & appearance / noises are disturbing. Failure is noticed by most customers (>75%). (<i>Almost all customers will notice the failure, even non-critical representatives!</i>) Disturbance of our senses: hearing / seeing / feeling / smelling / (tasting)
3	Annoyance Appearance or Audible Noise, vehicle operable, item does not conform. Defect noticed by many customers (50%)	Annoyance Appearance or Audible Noise, vehicle operable, item does not conform and noticed by many customers (50%).	Low Low function impairment of the vehicle, limitation of function of important service and comfort systems.	Perceived quality of appearance, sound or haptics unacceptable to many customers.	Fit & appearance / noises are disturbing. Failure is noticed by many customers (>50%). (<i>On average every second customer will notice the failure</i>) Disturbance of our senses: hearing / seeing / feeling / smelling / (tasting)
2	Annoyance Appearance or Audible Noise, vehicle operable, item does not conform. Defect noticed by discriminating customers (<25%)	Annoyance Appearance or Audible Noise, vehicle operable, item does not conform and noticed by discriminating customers (<25%).	Low Low function impairment of the vehicle, limitation of function of important service and comfort systems.	Perceived quality of appearance, sound or haptics unacceptable to some customers.	Fit & appearance / noises are disturbing. Failure is noticed by some customers (<25%). (Those customers can hear the grass growing. ☺) Disturbance of our senses: hearing / seeing / feeling / smelling / (tasting)
1	No effect No discernible effect.	No effect No discernible effect.	Very Low Very low function impairment, only identifiable by qualified personnel.	No discernible effect.	No discernible effect. Only identifiable by qualified personnel. (But out of tolerances; at this point the tolerances have to be discussed.)

Ranking Scales for Design-FMEA: Comparison of SAE J1739 / AIAG / VDA / yellow volume / proposal i-Q



OCCURENCE – Design-FMEA

0	SAE J1739 (status: 01/2009)	AIAG, FMEA 4 th edition (status: 06/2008) (events per object / vehicle)	VDA volume 4-II (Status: 06/2012) (defects ppm per vehicle life time)	VDA/AIAG yellow volume (Status: 11/2017) - Estimated Occurrence: - Product Experience - Prevention Controls	Proposal i-Q Schacht & Kollegen GmbH (Status: 03/2018)
10	Very High New technology / new design with no history.	Very High New technology / new design with no history. ≥ 100 per thousand 1 in 10	Very High New Development of systems / components without operating experience and / or under unexplained operating conditions. Known system with problems. (500.000 ppm)	Occurrence during intended service life cannot be determined at this time, no preventive controls, or occurrence during intended service life of the item is extremely high. First application of new technology anywhere without operating experience and / or under uncontrolled operating conditions. Use case or operating conditions vary widely and cannot be reliably predicted. Standards do not exist and best practices have not yet been determined. Analysis is not able to predict field performance.	New Development of systems / components without operating experience and / or under unexplained operating conditions. It is almost sure that failures will occur on a large scale.
9	High Failure is inevitable with new design, new application, or change in duty cycle / operating conditions.	High Failure is inevitable with new design, new application, or change in duty cycle / operating conditions. 50 per thousand 1 in 20	Very High New Development of systems / components without operating experience and / or under unexplained operating conditions. Known system with problems. (100.000 ppm)	Very high occurrence during intended service life of the item. First use of design with technical innovations or materials within the company. New use case, or change in duty cycle / operating conditions. Not previously validated. Newly developed for this design. First application of new standards with no experience. Analysis is not targeted to identify performance to specific requirements	New Development of systems / components without operating experience and / or under unexplained operating conditions. Highly frequent occurrence of the cause of the failure, unusable, inappropriate design concept or known system with problems.
8	High Failure is likely with new design, new application, or change in duty cycle / operating conditions.	High Failure is likely with new design, new application, or change in duty cycle / operating conditions. 20 per thousand 1 in 50	High New development of systems / components using new technologies and / or previously problematic technologies. Known system with problems. (30.000 ppm)	High occurrence during intended service life of the item. First use of design with technical innovations or materials on a new application. New application, or change in duty cycle / operating conditions. Not previously validated. Few existing standards and best practices, not directly applicable for this design. Analysis is not a reliable indicator of field performance.	New development of systems / components using new technologies and / or previously problematic technologies. Design generally conforms to designs that have repeatedly caused difficulties in the past .
7	High Failure is uncertain with new design, new application, or change in duty cycle / operating conditions.	High Failure is uncertain with new design, new application, or change in duty cycle / operating conditions. 10 per thousand 1 in 100	High New development of systems / components using new technologies and / or previously problematic technologies. Known system with problems. (10.000 ppm)	Moderately high occurrence during intended service life of the item. New design based on similar technology or materials. New application, or change in duty cycle / operating conditions. Not previously validated. Standards, best practices, and design rules apply to the baseline design, but not the innovations. Analysis provides limited indication of performance.	New development of systems / components using new technologies and / or previously problematic technologies. Cause of failure occurs repeatedly, problematic, immature design .
6	Moderate Frequent failures associated with similar designs or in design simulation and testing.	Moderate Frequent failure associated with similar design or in design simulation and testing. 2 per thousand 1 in 500	Moderate New development of systems / components with operating experience and / or detail changes to previous developments under comparable operating conditions. Mature system / components with long, failure-free series production experience under altered operating conditions. (5.000 ppm)	Moderate occurrence during intended service life of the item. Similar to previous designs, using existing technology and materials. Similar application, with changes in duty cycle or operating conditions. Previous testing or field experience. Standards and design rules exist but are insufficient to ensure that the failure will not occur. Analysis provides some ability to prevent a failure cause.	New development of systems / components with experience and / or detail changes to previous developments under comparable operating conditions. Cause of failure occurs repeatedly, not yet mature design .
5	Moderate Occasional failures associated with similar designs or in design simulation and testing.	Moderate Occasional failure associated with similar design or in design simulation and testing. 0,5 per thousand 1 in 2.000	Moderate New development of systems / components with operating experience and / or detail changes to previous developments under comparable operating conditions. Mature system / components with long, failure-free series production experience under altered operating conditions. (2.000 ppm)	Moderate occurrence during intended service life of the item. Detail changes to previous designs, using proven technology and materials. Similar application, duty cycle or operating conditions. Previous testing or field experience, or new design with some test experience related to the failure. Design addresses lessons learned from previous designs. Best practices re-evaluated for this design, but have not yet been proven. Analysis is capable of finding deficiencies in the system / component related to the effects of failure, and provides some indication of performance.	New development of systems / components with experience and / or detail changes to previous developments under comparable operating conditions. Design generally conforms to earlier designs that occasionally but not to a large extent failed .

Ranking Scales for Design-FMEA: Comparison of SAE J1739 / AIAG / VDA / yellow volume / proposal i-Q



0	SAE J1739 (status: 01/2009)	AIAG, FMEA 4 th edition (status: 06/2008) (events per object / vehicle)	VDA volume 4-II (Status: 06/2012) (defects ppm per vehicle life time)	VDA/AIAG yellow volume (Status: 11/2017) - Estimated Occurrence: - Product Experience - Prevention Controls	Proposal i-Q Schacht & Kollegen GmbH (Status: 03/2018)
4	Moderate Isolated failures associated with similar designs or in design simulation and testing.	Moderate Isolated failure associated with similar design or in design simulation and testing. 0,1 per thousand 1 in 10.000	Moderate New development of systems / components with operating experience and / or detail changes to previous developments under comparable operating conditions. Mature system / components with long, failure-free series production experience under altered operating conditions. (500 ppm)	Moderately low occurrence during intended service life of the item. Almost identical design with short-term field exposure. Similar application, with minor change in duty cycle or operating conditions. Previous testing or field experience. Predecessor design and changes for new design conform to best practices, standards, and specifications. Analysis is capable of finding deficiencies in the system / component related to the type of failure, and indicates likely design conformance.	New development of systems / components with experience and / or detail changes to previous developments under comparable operating conditions. Occasional cause of failure, suitable, stage of maturity with advanced design.
3	Low Only isolated failures associated with almost identical design or in design simulation and testing.	Low Only isolated failures associated with almost identical design or in design simulation and testing. 0,01 per thousand 1 in 100.000	Low New development of systems / components with positively completed proof procedure. Detail changes to mature systems / components with long, failure-free series production experience under comparable operating conditions. (100 ppm)	Low occurrence during intended service life of the item. Detail changes to known design (same application, with minor change in duty cycle or operating conditions) and testing or field experience under comparable operating conditions, or new design with successfully completed test procedure. Design expected to conform to standards and best practices, considering lessons learned from previous designs. Analysis is capable of finding deficiencies in the system / component related to the cause of failure, and predicts conformance of production design.	New development of systems / components with positively completed appropriate verification procedure. There are appropriate measures with a documented, positive result, e.g. simulations (FEM, etc.), tolerance calculations, specific tests and measurements etc.
2	Low No observed failures associated with almost identical design or in design simulation and testing.	Low No observed failures associated with almost identical design or in design simulation and testing. ≤ 0,001 per thousand 1 in 1.000.000	Low New development of systems / components with positively completed proof procedure. Detail changes to mature systems / components with long, failure-free series production experience under comparable operating conditions. (10 ppm)	Very low occurrence during intended service life of the item. Almost identical mature design with long term field exposure. Same application, with comparable duty cycle or operating conditions. Testing or field experience under comparable operating conditions. Design expected to conform to standards and best practices, considering lessons learned from previous designs. Analysis is capable of finding deficiencies in the system / component related to the failure, and indicates confidence in design conformance.	Detail changes of proven mature systems / components with long-term, faultless series production experience under comparable operating conditions. Design generally complies with earlier designs for which low failure rates were reported.
1	Very Low Failure is eliminated through preventative control.	Very Low Failure is eliminated through preventative control.	Very Low New development and / or mature systems / components with operating experience under comparable (differentiation to 3-2 necessary!) operating conditions with positively completed proof procedure. Mature system / components with long, failure-free series production experience under comparable operating conditions. (1 ppm)	Possibility of failures is virtually eliminated through preventive control and history of failure-free series production. Identical mature design. Same application, duty cycle and operating conditions. Testing or field experience under comparable operating conditions or mature design with long, failure-free series production experience under comparable operating conditions. Design proven to conform to standards and best practices, considering lessons learned which effectively prevents the failure from occurring. Analysis is capable of ensuring with high confidence that the failure cannot occur.	Proven mature system / components with experience under comparable operating conditions with positively completed verification procedure. Proven mature system / components with long-term, faultless series production experience under comparable operating conditions Design is similar to previous designs for which no failures are known.

Schacht & Kollegen
Qualitätskonstruktion GmbH

Ranking Scales for Design-FMEA: Comparison of SAE J1739 / AIAG / VDA / yellow volume / proposal i-Q



DETECTION – Design-FMEA

D	SAE J1739 (status: 01/2009)	AIAG, FMEA 4 th Ed. (status: 06/2008) (Opportunity – Likelihood)	VDA volume 4-II (status: 06/2012) (product design and customer use)	VDA/AIAG yellow volume (status: 11/2017)	Proposal i-Q Schacht & Kollegen GmbH (status: 03/2018) – (product design and customer use)
10	Absolute Uncertainty No current design control; Cannot be detect or is not analyzed.	No detection opportunity – Almost Impossible No current design control; Cannot be detect or not analyzed.	Very Low Failure with very low detection potential, since a proof procedure is not known and / or has not been established. It is impossible or improbable that the failure will be detected at all or on time. - No monitoring / no diagnostics of the functions to be monitored by the system - In diagnostics rarely detectable or only with very high expenditure	Absolute uncertainty No test or test procedure.	NOT detected: The test procedure within the range of design will not / cannot detect the potential cause / following failure or there is no check for this characteristic. - No monitoring / no diagnosis by the system of the function to be checked.
9	Difficult to Detect Design analysis / detection controls have a weak detection capability; Virtual Analysis (e.g. CAE, FEA, etc.) is <u>not correlated</u> to expected actual operating conditions.	Not likely to detect at any stage – Very Remote Design analysis / detection controls have a weak detection capability; Virtual Analysis (e.g. CAE, FEA, etc.) is <u>not correlated</u> to expected actual operating conditions.	Very Low Failure with very low detection potential, since a proof procedure is not known and / or has not been established. It is impossible or improbable that the failure will be detected at all or on time. - No monitoring / no diagnostics of the functions to be monitored by the system - In diagnostics rarely detectable or only with very high expenditure	Very remote Test procedure not designed to specifically detect the cause and / or failure mode.	Discovered coincidentally only: Very little chance that the test procedure can detect the failure or the cause, since no detection method is specified. - In the diagnosis hardly or only with great effort discoverable.
8	Post Design Freeze and Prior to Launch Product verification / validation after design freeze and prior to launch with <u>pass / fail</u> testing (Sub-system or system testing with acceptance criteria e.g. ride & handling, shipping evaluation, etc.).	Post Design Freeze and prior to launch – Remote Product verification / validation after design freeze and prior launch with <u>pass / fail</u> testing (subsystem or system testing with acceptance criteria such as ride and handling, shipping evaluation, etc.).	Low Failure with a low detection potential, since the proof procedure is uncertain and / or there is no experience with the established proof procedure. The probability is low that the failure will be detected at all or on time. - Monitoring / diagnostics of sub-scopes of the functions to be monitored are only done under certain operating conditions by the system or the operator. - Altered function, e.g. comfortable backup operation - Can only be detected during diagnostics with high expenditure	Remote Ability of detection control to detect the failure cause or failure mode is remote based on verification or validation procedure, sample size, mission profile, etc.	Accidentally discovered: Little chance that the test procedure can detect the failure or the cause, since detection methods are uncertain or no experience with the established detection methods exist. Failures are more likely to be discovered by accident. - Monitoring / diagnosis of partial scopes of the functions to be monitored respectively only under certain operating conditions by the system or the user - Altered function, e.g. comfortable replacement operation
7	Post Design Freeze and Prior to Launch Product verification / validation after design freeze and prior to launch with <u>test to failure</u> testing (Sub-system or system testing until failure occurs, testing of system interactions, etc.).	Post Design Freeze and prior to launch – Very Low Product verification / validation after design freeze and prior to launch <u>test to failure</u> testing (subsystem or system testing until failure occurs, testing of system interactions, etc.).	Low Failure with a low detection potential, since the proof procedure is uncertain and / or there is no experience with the established proof procedure. The probability is low that the failure will be detected at all or on time. - Monitoring / diagnostics of sub-scopes of the functions to be monitored are only done under certain operating conditions by the system or the operator. - Altered function, e.g. comfortable backup operation - Can only be detected during diagnostics with high expenditure	Very low Ability of detection control to detect the failure cause or failure mode is very low based on verification or validation procedure, sample size, mission profile, etc.	Very low probability: Very few chances that the test measure can detect the failure or the cause, since detection methods are not certain or have little experience with the established detection methods. - Monitoring / diagnosis of partial scopes of the functions to be monitored respectively only under certain operating conditions by the system or the user - Discoverable only with great effort during diagnosis.
6	Post Design Freeze and Prior to Launch Product verification / validation after design freeze and prior to launch with <u>degradation</u> testing (Sub-system or system testing after durability test e.g. function check).	Post Design Freeze and prior to launch – Low Product verification / validation after design freeze and prior to launch with <u>degradation</u> testing (subsystem or system testing after durability test, e.g., function check).	Moderate Failure with a moderate detection potential. Mature proof procedure from comparable products under new usage / boundary conditions. The probability is moderate that the failure will be detected at all or on time. - Monitoring / diagnostics of sub-scopes of the functions to be monitored by the system. - Function failure / backup operation and / or with warning to the operator by, for example, statically actuated warning light. - Can be detected during diagnostics with acceptable expenditure	Low Ability of detection control to detect the failure cause or failure mode is low based on verification or validation procedure, sample size, mission profile, etc.	Low probability: Few chances that the test measure can detect the failure or the cause. Proven detection method from comparable products under completely new operational / general conditions. - Discoverable at diagnosis only with reasonable effort.
5	Prior to Design Freeze Product validation (reliability testing, development or validation tests) prior to design freeze using <u>pass / fail</u> testing (e.g. acceptance criteria for performance, function checks, etc.).	Prior to Design Freeze – Moderate Product validation (reliability testing, development or validation tests) prior to design freeze using <u>pass / fail</u> testing (e.g., acceptance criteria for performance, function checks, etc.).	Moderate Failure with a moderate detection potential. Mature proof procedure from comparable products under new usage / boundary conditions. The probability is moderate that the failure will be detected at all or on time. - Monitoring / diagnostics of sub-scopes of the functions to be monitored by the system. - Function failure / backup operation and / or with warning to the operator by, for example, statically actuated warning light. - Can be detected during diagnostics with acceptable expenditure	Moderate Ability of detection control to detect the failure cause or failure mode is moderate based on verification or validation procedure, sample size, mission profile, etc.	Moderate probability: Medium opportunities that the test measure can detect the failure or cause. Proven detection method from comparable products under changed operational / general conditions. - Monitoring / diagnosis of partial scopes of the functions to be monitored by the system

Ranking Scales for Design-FMEA: Comparison of SAE J1739 / AIAG / VDA / yellow volume / proposal i-Q



D	SAE J1739 (status: 01/2009)	AIAG, FMEA 4 th Ed. (status: 06/2008) (Opportunity – Likelihood)	VDA volume 4-II (status: 06/2012) (product design and customer use)	VDA/AIAG yellow volume (status: 11/2017)	Proposal i-Q Schacht & Kollegen GmbH (status: 03/2018) – (product design and customer use)
4	Prior to Design Freeze Product validation (reliability testing, development or validation tests) prior to design freeze using test to failure (e.g. until leaks, yields, cracks, etc.).	Prior to Design Freeze – Moderately Product validation (reliability testing, development or validation tests) prior to design freeze using test to failure (e.g., until leaks, yields, cracks, etc.).	Moderate Failure with a moderate detection potential. Mature proof procedure from comparable products under new usage / boundary conditions. The probability is moderate that the failure will be detected at all or on time. - Monitoring / diagnostics of sub-scopes of the functions to be monitored by the system. - Function failure / backup operation and / or with warning to the operator by, for example, statically actuated warning light. - Can be detected during diagnostics with acceptable expenditure	Moderately high Ability of detection control to detect the failure cause or failure mode is moderately high based on verification or validation procedure, sample size, mission profile, etc.	Reasonable probability: Moderately high chances that the test measure can detect the error or the cause. Proven detection method from comparable products under similar operational / general conditions. - Functional failure / replacement operation and / or warning of the user e.g. by statically controlled warning lamp
3	Prior to Design Freeze Product validation (reliability testing, development or validation tests) prior to design freeze using degradation testing (e.g. data trends, before / after values. etc.).	Prior to Design Freeze – High Product validation (reliability testing, development or validation tests) prior to design freeze using degradation testing (e.g., data trends, before / after values, etc.).	High Failure with a high detection potential due to mature proof procedure. The effectiveness of the detection action has been demonstrated for this product. The probability is high that the failure will be detected on time. - Monitoring and diagnostics of the functions to be monitored done by the system. - Failure and backup operation with clearly perceptible impairment and / or with a warning to the user by, for example, flashing warning lights. - Detectable during diagnostics easily with little expenditure, for example, during routine service	High Ability of detection control to detect the failure cause or failure mode is high based on verification or validation procedure, sample size, mission profile, etc.	High probability: High chances that the test measure can detect the error or the cause. Proven detection method , efficacy has been demonstrated for this product under similar conditions. - Functional failure and replacement operation with clearly noticeable impairment and / or warning of the user e.g. by flashing warning light.
2	Virtual Analysis – Correlated Design analysis / detection controls have a strong detection capability. Virtual Analysis (e.g. CAE, FEA, etc.) is highly correlated with actual and / or expected operating conditions prior to design freeze.	Virtual Analysis – Correlated – Very High Design analysis / detection controls have a strong detection capability. Virtual analysis (e.g., CAE, FEA, etc.) is highly correlated with actual or expected operating conditions prior to design freeze.	High Failure with a high detection potential due to mature proof procedure. The effectiveness of the detection action has been demonstrated for this product. The probability is high that the failure will be detected on time. - Monitoring and diagnostics of the functions to be monitored done by the system. - Failure and backup operation with clearly perceptible impairment and / or with a warning to the user by, for example, flashing warning lights. - Detectable during diagnostics easily with little expenditure, for example, during routine service	Very high Ability of detection control to detect the failure cause or failure mode is very high based on verification or validation procedure, sample size, mission profile, etc.	Very high probability: Very high chances that the test measure can detect the error or the cause. Proven detection method , efficiency has been demonstrated for this product. - Discoverable safely with little effort in the diagnosis, e.g. through service routine.
1	Detection not applicable; Failure Prevention Failure cause or failure mode cannot occur because it is fully prevented through design solutions (e.g. proven design standard / best practice or common material, etc.).	Detection not applicable; Failure Prevention – Almost Certain Failure cause or failure mode cannot occur because it is fully prevented through design solutions (e.g., proven design standard, best practice or common material, etc.).	Very High Failure with a very high detection potential due to mature proof procedure of previous generation. The effectiveness of the detection action has been demonstrated for this product. The failure is detected easily and on time. - High quality and independent monitoring and diagnostics of the functions to be monitored done by the system. - No common cause-effects actions imaginable between failure cause and detection actions imaginable whatsoever. Failure / backup operation with very clearly perceptible impairment or with very clearly perceptible warning to the user for example, through an acoustic signal. - Due to self-diagnostics / display, easily detectable by the user or the diagnostics without additional test equipment	Almost certain Design proven to conform to standards and best practices, considering lessons learned and detection actions of previous generations, which effectively prevents the failure from occurring.	Certainly: The test procedure within the range of design will almost certainly detect the fault or the cause. Proven detection method , the efficiency has been proven for this product already in the previous generation. - No common cause effects between fault cause and detection measure imaginable. Functional failure / replacement operation with clearly noticeable impairment and / or with clearly perceptible warning of the user e.g. by an acoustic signal. - By self-diagnostics / display without additional test equipment safely discoverable by the user or the diagnosis.

Ranking Scales for Design-FMEA: Comparison of SAE J1739 / AIAG / VDA / yellow volume / proposal i-Q

With our (i-Q GmbH) proposed rankings and statements we reference to the following tables (status: February 2018):

- A. SAE J1739 (SAE International, https://www.sae.org/standards/content/j1739_200208/)
- B. AIAG FMEA (FMEA, 4th Edition 06/2008)
- C. VDA (Chapter 4: Product- and Process-FMEA, 2nd Edition 12/2006, updated 06/2012)
- D. AIAG / VDA FMEA Alignment (VDA yellow volume, withdrawn 28.02.2018)

Explanation of why we at i-Q GmbH come to these proposals.

- 1) It is completely unsatisfactory if several rankings (3-4-5) are provided with the same text. How should a concrete distinction be made?
- 2) In the high severity rankings, we argue that it is quite irrelevant for the driver (and anyone else involved) to have a message in a dangerous situation: "You are seriously injured or even dead!" Furthermore, we are still considering that health and life of people are "slightly more" important than compliance with legal regulations. Therefore, we are making distinction in meaning as follows (without going to the topic of warning or no warning):
 - i. 10: Life and health of humans is endangered
 - ii. 9: Noncompliance with legal requirements
- 3) Then for us the next ranking step (8 and 7) is dedicated very consequent to the inspection of the vehicle's primary functions (to drive from A to B).
 - i. 8: Vehicle stops (no impairment of health and life of humans are endangered or government regulations)! Or we speak of a so called „Walk Home Failure“ – vehicle stands still => driver has to walk home. The vehicle has to be brought into garage by service car.
 - ii. 7: The vehicle is operable, but on a reduced level. That will be called „Limp Home Failure“ - e.g. limited revolutions / torque / speed – vehicle can be driven in reduced mode only! So I could drive to a garage by myself (no service car necessary), but long distances would become absolute torture.
- 4) Let's have a look at secondary functions / comfort functions. Similar to the primary functions we differentiate between „is not operable“ and „is reduced operable“. Consequential that rating will follow:
 - i. 6: comfort functions are not working (Navi / window lifter / radio / air condition), but vehicle is operable without reduced level of performance.
 - ii. 5: comfort functions are working on a reduced level / decelerated (Navi: decelerated reaction/ window lifter: takes a long time / radio: one radio station only / air condition: isn't cooling with full capacity), but vehicle is operable without reduced level of performance.
- 5) In this rating area it's not about deficient functions, but about our five (four) senses.
 - Hear – auditive / acoustical (rattling, rubbing, knocking, squeaking, ...);
 - See – visual / optical (clearance, displacement of colours, the look simply "sucks", ...),
 - Smell – olfactory (stinky, musty, painful, ...),
 - Feel – tactile / haptic (uncomfortable, cold, cheap, ...),
 - Taste – gustative (that will not be relevant, because: who will lick at his car by choice!)
 - i. 4: Nearly most of the drivers / users (>75%) will feel a difference.
 - ii. 3: Circa half of the drivers / users (~ 50%) will feel disturbed / impaired.
 - iii. 2: Only some drivers / users (<25%) will notice (even the "nitpickers" or more politically correct: „the very sensitive representatives“).
- 6) It is a deviation to specifications, but no customer will ever notice the non-conforming.
 - i. 1: Only identifiable by qualified personnel.
- 7) Looking at Occurrence we will focus on comparison to previous projects, by reason that original comparison figures (e.g.: 1 of 1.000) have no evidence for us within the development area.
- 8) As well as at Detection we **don't** refer to former comparison figures, but mode of discovery measures and their gained experiences.

IMPORTANT: Document company-specific examples (own pages) for your ratings, to whom you always can refer!

Schacht & Kollegen
Qualitätskonstruktion GmbH